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### **Supplemental Material**

## **Low Greenhouse Gas Emission Self-Selective Diets and Risk of Metabolic Syndrome in Adults 40 and Older: A Prospective Cohort Study in South Korea**

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**Table S1.** GHG emissions associated with Korean representative foods according to HEXA 106-item FFQ data.

Food name	kg CO <sub>2</sub> eq/1,000 kcal	kg CO <sub>2</sub> eq/kg	Reference
Cooked rice	0.30	0.51	MOE <sup>1</sup>
Cooked rice with soybean	0.70	1.17	FACT <sup>2</sup>
Cooked rice with other grains	0.60	0.93	MOE
50/50 well-milled cooked rice and rice with soybean	0.60	0.93	MOE
50/50 well-milled cooked rice and rice with other grains	0.60	0.93	MOE
Ramen	2.30	2.34	KEITI <sup>3</sup>
Wheat noodles with soup	4.90	3.45	MOE
Chajangmyon/Jambbong	1.00	1.27	FACT
Buckwheat vermicelli/Buckwheat noodles	17.20	11.84	FACT
Dumpling/Dumpling with soup	2.60	3.45	MOE
Rice cake (plain rod shape)/rice cake with soup	5.60	4.96	FACT
Other rice cakes	1.20	2.49	KEITI
Grains, corn flakes	0.40	1.68	KEITI
Loaf bread/Sandwich/Toast	0.20	0.52	Clune, S. <sup>4</sup>
Jam/Honey/Butter/Margarine	1.30	3.70	Clune, S.
Bread with small amount of red bean	1.40	3.45	MOE
Cakes/Choco pie	0.10	0.38	KEITI
Pizza/Hamburger	1.30	3.45	MOE
Parched grains powder	1.80	7.31	FACT
Cookie/Cracker/Snack	0.60	3.14	KEITI
Candy/Chocolate	0.20	0.91	KEITI
Nuts	0.20	1.10	Clune, S.
Legumes	3.10	8.50	MOE
Soup and stew with soybean paste/soybean paste	3.10	0.71	MOE
Eggs	1.40	2.01	MOE
Tofu	0.50	0.53	MOE
Potatoes	0.40	0.30	Clune, S.
Sweet potatoes	0.20	0.30	Clune, S.
Starch vermicelli	4.00	5.14	FACT
Kimchi, Korean cabbage	4.00	1.00	MOE
Kkakdugi/small radish Kimchi	2.30	0.88	MOE
Kimchi, Radish with water	1.70	0.12	FACT
Other Kimchies	3.60	3.20	FACT
Korean style pickles	1.70	2.12	FACT
Radish/Salted radish	12.00	0.12	MOE
Korean cabbages / Korean cabbage soup	0.70	0.12	MOE
Spinach	4.00	0.91	Clune, S.
Lettuce	4.00	0.60	Clune, S.
Perilla leaf	2.30	1.09	MOE
Vegetables wrap/Vegetable salad	1.40	0.38	Clune, S.
Other green vegetables	1.00	0.38	Clune, S.
Deoduck/Doraji	0.80	0.38	Clune, S.
Bean sprouts	2.40	0.86	MOE
Bracken/Sweet potato stalk/Stem of taro	1.70	0.38	Clune, S.
Oyster mushroom	24.10	4.34	MOE
Other mushrooms	20.70	4.34	MOE
Pepper leaves/Chamnamul/Asters caber	0.80	0.38	Clune, S.
Crown daisy/Leek/Water dropwort	7.30	1.09	MOE
Cucumber	31.00	4.34	MOE
Carrot/Carrot juice	0.50	0.16	Clune, S.
Onion	1.40	0.38	MOE
Green pepper	1.50	0.43	FACT
Pumpkin, immature	22.30	4.90	FACT

Pumpkin, mature/Pumpkin juice	0.70	0.25	Clune, S.
Pork, belly	1.00	4.25	MOE
Pork, roasted	7.40	34.80	MOE
Pork, braised	1.90	4.25	MOE
Ham/Sausage	2.00	3.26	MOE
Edible viscera	21.80	35.90	Scarborough, P. <sup>5</sup>
Steak/Beef, roasted	11.20	44.71	MOE
Fried chicken/Chicken stew	2.40	6.00	Clune, S.
Beef soup	33.00	82.74	FACT
Beef soup with vegetables	12.40	15.52	FACT
Sashimi	3.40	3.60	Clune, S.
Mackerel/Pacific saury/Spanish mackerel	0.60	1.80	MOE
Hair tail	1.20	1.80	MOE
Eel	1.60	3.88	Clune, S.
Yellow croaker/Sea bream/Flat fish	0.50	1.80	MOE
Alaska pollack	1.00	2.79	MOE
Cuttlefish/Octopus	1.80	6.39	Clune, S.
Dried anchovy	0.80	2.00	MOE
Tuna, canned	1.00	1.70	Clune, S.
Salt-fermented fish	1.50	2.50	MOE
Clam/Whelk	2.70	2.90	MOE
Oyster	0.10	0.04	MOE
Crab	3.80	2.90	MOE
Shrimp	4.00	2.90	MOE
Fish paste/Crab flavored	1.60	1.82	KEITI
Laver, dried	3.50	10.70	KEITI
Kelp/Sea mustard	0.30	0.04	MOE
Milk	1.90	1.23	MOE
Yogurt	2.00	1.31	Clune, S.
Ice cream	1.10	2.02	KEITI
Cheese	1.90	5.45	Clune, S.
Carbonated drinks	1.20	0.47	KEITI
Soybean milk	1.00	0.70	Clune, S.
Coffee	252.50	10.10	Scarborough, P.
Coffee Sugar	0.20	0.84	MOE
Coffee cream	1.00	2.40	Scarborough, P.
Green tea	0.50	1.90	Scarborough, P.
Other drinks	1.00	0.75	MOE
Strawberry	1.30	0.45	FACT
Muskmelon/Melon	1.70	0.80	FACT
Watermelon	1.10	0.35	FACT
Peach/Plum	2.90	1.40	FACT
Banana	0.50	0.42	Clune, S.
Persimmon, hard/Persimmon, dried	0.30	0.20	FACT
Tangerine	0.60	0.20	FACT
Pear/Pear juice	1.80	0.85	FACT
Apple/Apple juice	1.00	0.50	FACT
Orange/Orange juice	0.90	0.41	Clune, S.
Grape/Grape juice	0.70	0.40	FACT
Tomato/Cherry tomato/Tomato juice	6.80	1.29	FACT

GHG emissions are generated by the authors from an analysis of data collected through a related literature review. GHG emissions are expressed by carbon footprint.

CO<sub>2</sub>eq: carbon dioxide equivalents; FACT, The Foundation of Agriculture Technology Commercialization and Transfer; FFQ: food frequency questionnaire; GHG emissions: greenhouse gas emissions; HEXA: Health Examinee study; KEITI, Korea Environmental Industry & Technology Institute; MOE, Ministry of Environment.

<sup>1</sup> Ministry of Environment. Research of energy consumption and calculation of GHG emissions from food. [http://www.prism.go.kr/homepage/entire/retrieveEntireDetail.do?jsessionid=C522AA26D52926E04DC20F694BF9A5C0.node02?cond\\_research\\_name=&cond\\_research\\_start\\_date=&cond\\_research\\_end\\_date=&research\\_id=1480000-201100468&pageIndex=1462&leftMenuLevel=160](http://www.prism.go.kr/homepage/entire/retrieveEntireDetail.do?jsessionid=C522AA26D52926E04DC20F694BF9A5C0.node02?cond_research_name=&cond_research_start_date=&cond_research_end_date=&research_id=1480000-201100468&pageIndex=1462&leftMenuLevel=160). Published 2020.

<sup>2</sup> The Foundation of Agriculture Technology Commercialization and Transfer. Smart Green Food. [http://www.smartgreenfood.org/jsp/front/story/story03\\_1.jsp](http://www.smartgreenfood.org/jsp/front/story/story03_1.jsp). Published 2020. Accessed 2020.12, 2020.12.

<sup>3</sup> Korea Environmental Industry & Technology Institute. Carbon Footprint of Products. <http://www.epd.or.kr/eng/main.do>. Published 2020

<sup>4</sup> Clune S, Crossin E, Verghese K. Systematic review of greenhouse gas emissions for different fresh food categories. *Journal of Cleaner Production* 2017; 140: 766-783, 10.1016/j.jclepro.2016.04.082.

<sup>5</sup> Scarborough P, Appleby P N, Mizdrak A, Briggs A D, Travis R C, Bradbury K E, et al. Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK. *Clim Change* 2014; 125(2): 179-192, PMID: 25834298, 10.1007/s10584-014-1169-1.

**Table S2.** GHG emissions (kg CO<sub>2</sub> eq) per main food group in Korean Food Balance Wheel according to quintiles of energy-adjusted GHG emissions (N=41,659 from the HEXA Study, South Korea).

	Energy-adjusted dietary GHG emissions				
	Q1	Q2	Q3	Q4	Q5
Male, n=12,846					
Cereal	0.68 ± 0	0.77 ± 0	0.82 ± 0.01	0.86 ± 0.01	0.88 ± 0.01
Vegetables	0.21 ± 0	0.28 ± 0	0.31 ± 0	0.35 ± 0	0.40 ± 0.01
Fruits	0.07 ± 0	0.10 ± 0	0.11 ± 0	0.12 ± 0	0.12 ± 0
Dairy products	0.09 ± 0	0.14 ± 0	0.15 ± 0	0.16 ± 0	0.17 ± 0
Eggs, legumes, and meat	0.43 ± 0.01	0.74 ± 0.01	1.07 ± 0.01	1.58 ± 0.01	3.07 ± 0.03
Beef	0.14 ± 0	0.28 ± 0	0.46 ± 0.01	0.72 ± 0.01	1.65 ± 0.02
Pork	0.16 ± 0	0.29 ± 0	0.42 ± 0.01	0.64 ± 0.01	1.15 ± 0.02
Poultry	0.01 ± 0	0.02 ± 0	0.02 ± 0	0.03 ± 0	0.04 ± 0
Fish	0.06 ± 0	0.08 ± 0	0.10 ± 0	0.11 ± 0	0.14 ± 0
Eggs and legumes	0.05 ± 0	0.06 ± 0	0.07 ± 0	0.08 ± 0	0
Female, n=28,813					
Cereal	0.64 ± 0	0.71 ± 0	0.72 ± 0	0.74 ± 0	0.76 ± 0.01
Vegetables	0.22 ± 0	0.29 ± 0	0.34 ± 0	0.38 ± 0	0.43 ± 0
Fruits	0.11 ± 0	0.14 ± 0	0.15 ± 0	0.16 ± 0	0.16 ± 0
Dairy products	0.12 ± 0	0.17 ± 0	0.20 ± 0	0.21 ± 0	0.21 ± 0
Eggs, legumes, and meat	0.33 ± 0	0.58 ± 0	0.85 ± 0.01	1.25 ± 0.01	2.50 ± 0.02
Beef	0.10 ± 0	0.21 ± 0	0.35 ± 0	0.56 ± 0.01	1.35 ± 0.02
Pork	0.11 ± 0	0.20 ± 0	0.31 ± 0	0.48 ± 0.01	0.89 ± 0.01
Poultry	0.01 ± 0	0.02 ± 0	0.02 ± 0	0.03 ± 0	0.04 ± 0
Fish	0.06 ± 0	0.08 ± 0	0.10 ± 0	0.11 ± 0	0.13 ± 0
Eggs and legumes	0.04 ± 0	0.06 ± 0	0.07 ± 0	0.08 ± 0	0.08 ± 0

Daily diet components in Korean Food Balance Wheel mainly are classified into five groups: cereals, vegetables, fruits, dairy products, and eggs/legumes/meats. In current analyses, we further divided “eggs/legumes/meats” group into five subgroups: beef, pork, poultry, fish, and eggs/legumes. Energy-adjusted daily diet GHG emission was standardized by 2000 kcal/day. Q1 group means the lowest daily dietary energy-adjusted GHG emissions and Q5 has the highest emissions. Corresponding percentage proportions of GHG emissions per main food group in Korean Food Balance Wheel according to quintiles of energy-adjusted GHG emissions was shown in Figure S2.

**Table S3.** Serving sizes (servings/day) per main food group in Korean Food Balance Wheel according to quintiles of energy-adjusted GHG emissions (N=41,659 participants in the HEXA Study, South Korea).

	Energy-adjusted dietary GHG emissions				
	Q1	Q2	Q3	Q4	Q5
Male, n=12,846					
Cereal	3.70 ± 0.02	3.76 ± 0.02	3.78 ± 0.02	3.79 ± 0.02	3.73 ± 0.02
Vegetables	5.12 ± 0.06	6.34 ± 0.07	6.98 ± 0.08	7.61 ± 0.08	8.52 ± 0.1
Fruits	0.93 ± 0.02	1.19 ± 0.02	1.27 ± 0.02	1.35 ± 0.02	1.38 ± 0.02
Dairy products	1.25 ± 0.02	1.63 ± 0.03	1.71 ± 0.03	1.78 ± 0.03	1.79 ± 0.03
Eggs, legumes, and meat	1.65 ± 0.02	2.16 ± 0.03	2.55 ± 0.03	2.99 ± 0.03	4.03 ± 0.04
Beef	0.05 ± 0	0.10 ± 0	0.17 ± 0	0.28 ± 0.01	0.72 ± 0.02
Pork	0.11 ± 0	0.17 ± 0	0.23 ± 0	0.32 ± 0	0.52 ± 0.01
Poultry	0.03 ± 0	0.04 ± 0	0.05 ± 0	0.06 ± 0	0.09 ± 0
Fish	0.78 ± 0.02	1.01 ± 0.02	1.15 ± 0.02	1.31 ± 0.02	1.59 ± 0.02
Eggs and legumes	0.68 ± 0.01	0.84 ± 0.01	0.95 ± 0.02	1.02 ± 0.02	1.11 ± 0.02
Female, n=28,813					
Cereal	3.45 ± 0.01	3.48 ± 0.01	3.43 ± 0.01	3.39 ± 0.01	3.29 ± 0.02
Vegetables	5.20 ± 0.04	6.45 ± 0.05	7.12 ± 0.05	7.90 ± 0.06	8.62 ± 0.07
Fruits	1.36 ± 0.02	1.66 ± 0.02	1.77 ± 0.02	1.87 ± 0.02	1.82 ± 0.02
Dairy products	1.09 ± 0.01	1.45 ± 0.02	1.60 ± 0.02	1.66 ± 0.02	1.66 ± 0.02
Eggs, legumes, and meat	1.65 ± 0.02	2.22 ± 0.02	2.57 ± 0.02	3.01 ± 0.02	3.72 ± 0.03
Beef	0.04 ± 0	0.08 ± 0	0.13 ± 0	0.21 ± 0	0.50 ± 0.01
Pork	0.08 ± 0	0.13 ± 0	0.17 ± 0	0.24 ± 0	0.40 ± 0
Poultry	0.03 ± 0	0.04 ± 0	0.05 ± 0	0.06 ± 0	0.09 ± 0
Fish	0.82 ± 0.01	1.05 ± 0.01	1.21 ± 0.01	1.38 ± 0.02	1.58 ± 0.02
Eggs and legumes	0.68 ± 0.01	0.93 ± 0.01	1.02 ± 0.01	1.12 ± 0.01	1.15 ± 0.01

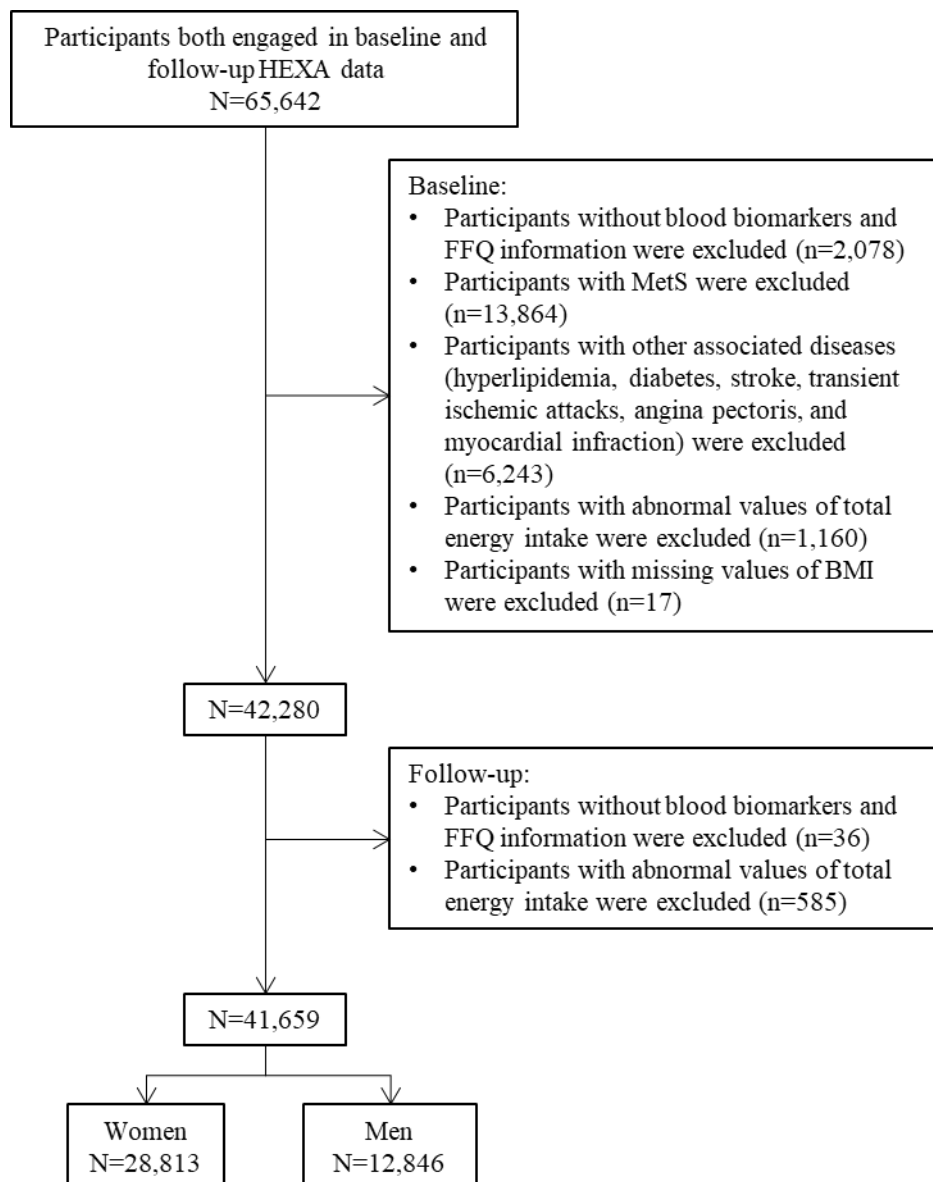
Daily diet components in Korean Food Balance Wheel mainly are classified into five groups: cereals, vegetables, fruits, dairy products, and eggs/legumes/meats. In current analyses, we further divided “eggs/legumes/meats” group into five subgroups: beef, pork, poultry, fish, and eggs/legumes. Energy-adjusted daily diet GHG emission was standardized by 2000 kcal/day. Q1 group means the lowest daily dietary energy-adjusted GHG emissions and Q5 has the highest emissions. Corresponding intake percentage proportions of each main food group in Korean Food Balance Wheel according to quintiles of energy-adjusted GHG emissions was shown in Figure S3.

**Table S4.** MetS biomarkers collected at follow-up of the study participants from the Health Examinees Study according to the quintiles of the energy-adjusted diet-related GHG emissions ( $n = 41,659$ ).

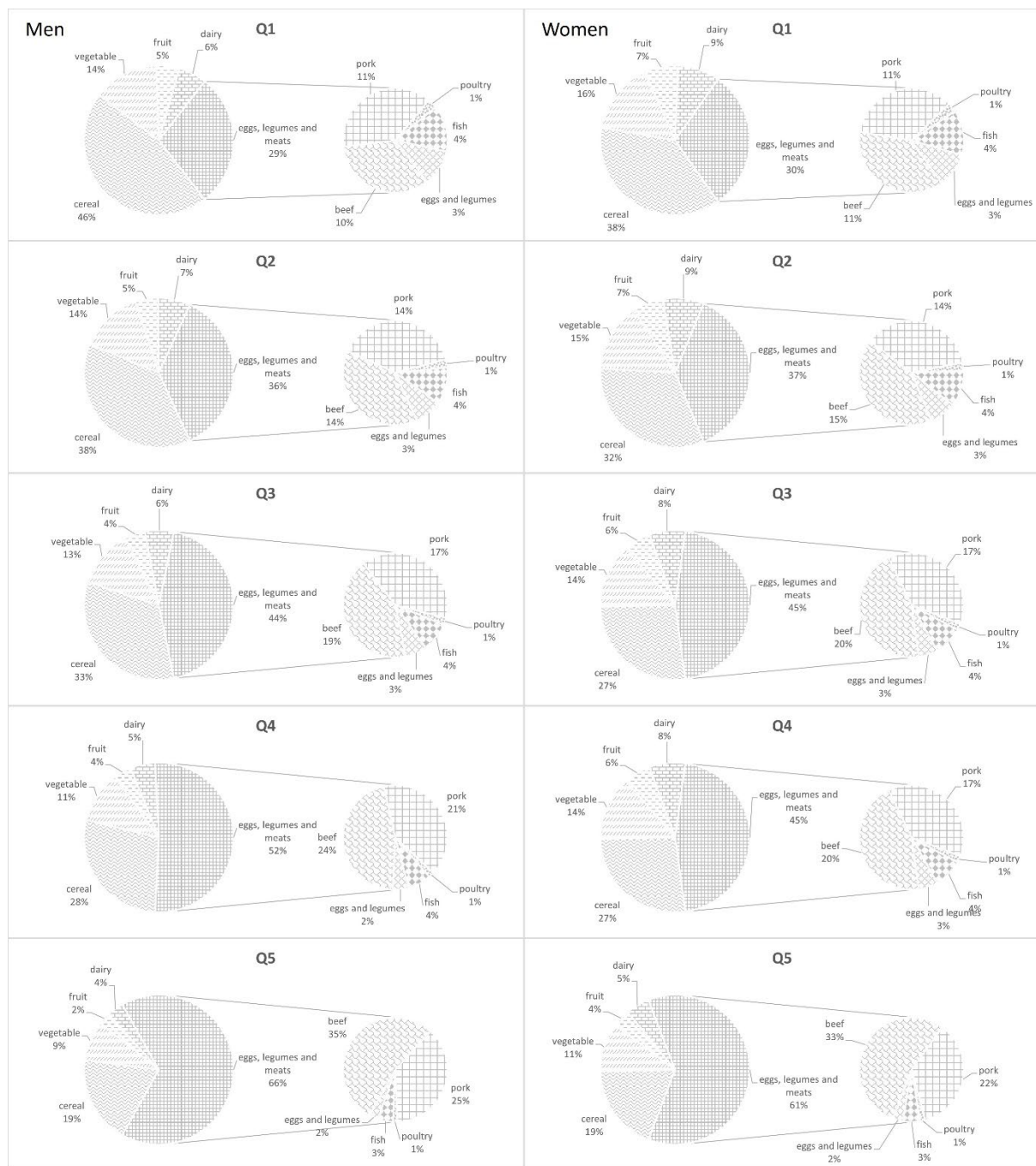
	Energy-adjusted diet-related GHG emissions					<i>p</i> -value
	Q1	Q2	Q3	Q4	Q5	
Males ( $n = 12,846$ )	2569	2569	2570	2569	2569	
TG (mg/dL)	123.16 $\pm$ 1.53b	123.66 $\pm$ 1.58b	124.64 $\pm$ 1.57b	125.72 $\pm$ 1.52b	131.58 $\pm$ 1.77a	0.0011
WC (cm)	83.57 $\pm$ 0.14c	84.04 $\pm$ 0.14ab	83.87 $\pm$ 0.14bc	84.3 $\pm$ 0.14a	84.34 $\pm$ 0.14a	0.0004
HDL-C (mg/dL)	54.7 $\pm$ 0.27b	55.06 $\pm$ 0.28ab	55.74 $\pm$ 0.27a	55.67 $\pm$ 0.27a	55.62 $\pm$ 0.27a	0.0255
FPG (mg/dL)	99.13 $\pm$ 0.27a	98.73 $\pm$ 0.29a	99.23 $\pm$ 0.29a	98.72 $\pm$ 0.29a	98.78 $\pm$ 0.28a	0.5879
DBP (mmHg)	76.23 $\pm$ 0.18a	76.37 $\pm$ 0.19a	76.5 $\pm$ 0.19a	76.37 $\pm$ 0.19a	76.31 $\pm$ 0.19a	0.8838
SBP (mmHg)	124.6 $\pm$ 0.27a	124.91 $\pm$ 0.28a	124.85 $\pm$ 0.28a	124.3 $\pm$ 0.27a	124.37 $\pm$ 0.27a	0.4062
Females ( $n = 28,813$ )	5762	5763	5763	5763	5762	
TG (mg/dL)	105.73 $\pm$ 0.66a	105.52 $\pm$ 0.67a	105.7 $\pm$ 0.72a	104.24 $\pm$ 0.67a	105.14 $\pm$ 0.72a	0.5177
WC (cm)	77.5 $\pm$ 0.1a	77.42 $\pm$ 0.1a	77.36 $\pm$ 0.1ab	77.09 $\pm$ 0.1bc	76.86 $\pm$ 0.1c	<.0001
HDL-C (mg/dL)	62.16 $\pm$ 0.19c	62.93 $\pm$ 0.2b	63.44 $\pm$ 0.2ab	63.62 $\pm$ 0.2a	63.7 $\pm$ 0.2a	<.0001
FPG (mg/dL)	94.28 $\pm$ 0.14a	94.05 $\pm$ 0.14a	93.97 $\pm$ 0.14a	93.88 $\pm$ 0.15a	93.87 $\pm$ 0.14a	0.2452
DBP (mmHg)	72.87 $\pm$ 0.13ab	73.07 $\pm$ 0.13a	72.47 $\pm$ 0.13c	72.53 $\pm$ 0.13c	72.27 $\pm$ 0.13c	<.0001
SBP (mmHg)	119.74 $\pm$ 0.19a	119.74 $\pm$ 0.19a	118.96 $\pm$ 0.19b	118.81 $\pm$ 0.19b	118.49 $\pm$ 0.19b	<.0001

*p*-values were calculated using generalized linear models. A post-hoc test was performed by a Duncan test and the mean values with the same letters in each row were not significantly different. The energy-adjusted GHG emission was standardized by 2000 kcal/day. The Q1 group had the lowest daily energy-adjusted diet-related GHG emissions and the Q5 group had the highest emissions.

DBP, diastolic blood pressure; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; MetS, metabolic syndrome; Q, quintile; SBP, systolic blood pressure; TG, triglycerides; WC, waist circumference.

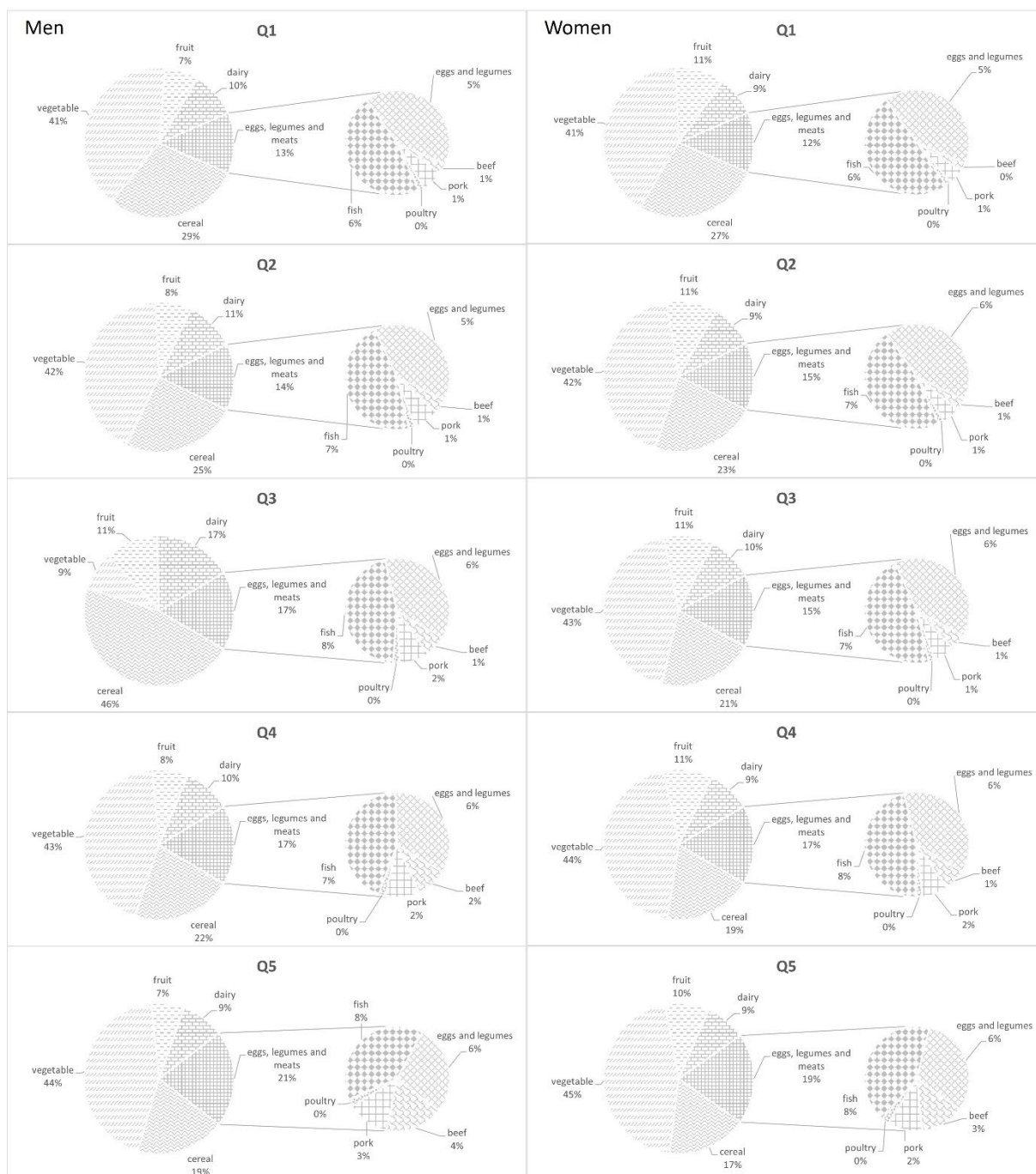


**Figure S1.** Flowchart of the selection of study participants



**Figure S2.** Percentage proportions of GHG emissions per main food group in Korean Food Balance Wheel according to quintiles of energy-adjusted GHG emissions.

Daily diet components in Korean Food Balance Wheel mainly are classified into five groups: cereals, vegetables, fruits, dairy products, and eggs/legumes/meats. In current analyses, we further divided “eggs/legumes/meats” group into five subgroups: beef, pork, poultry, fish, and eggs/legumes. Energy-adjusted daily diet GHG emission was standardized by 2000 kcal/day. Q1 group means the lowest daily dietary energy-adjusted GHG emissions and Q5 has the highest emissions. Food-group-level GHG emission profiles associated with mean daily diet consumption by Korean adults are shown as a percentage. Corresponding numeric data is shown in Table S2.



**Figure S3.** Serving proportions of the main food groups in Korean Food Balance Wheel according to quintiles of energy-adjusted GHG emissions.

Daily diet components in Korean Food Balance Wheel mainly are classified into five groups: cereals, vegetables, fruits, dairy products, and eggs/legumes/meats. In current analyses, we further divided “eggs/legumes/meats” group into five subgroups: beef, pork, poultry, fish, and eggs/legumes. Energy-adjusted daily diet GHG emission was standardized by 2000 kcal/day. Q1 group means the lowest daily dietary energy-adjusted GHG emissions and Q5 has the highest emissions. The serving sizes of the primary self-selected diet groups are shown as percentages. Detailed information regarding each diet group according to GHG emissions is provided in Table S3.